THE ROYAL AERONAUTICAL SOCIETY WAS FOUNDED IN 1866

MARCH, 1944
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Vol. XLVIII.

MONTHLY
PRICE
5/-

The Journal of the Royal Aeronautical Society

which is incorporated The Institution of Aeronautical Engineers

Edited for the Council by Capt. J. LAURENCE PRITCHARD, Hon. Fellow

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Daily Mail 4-2-44

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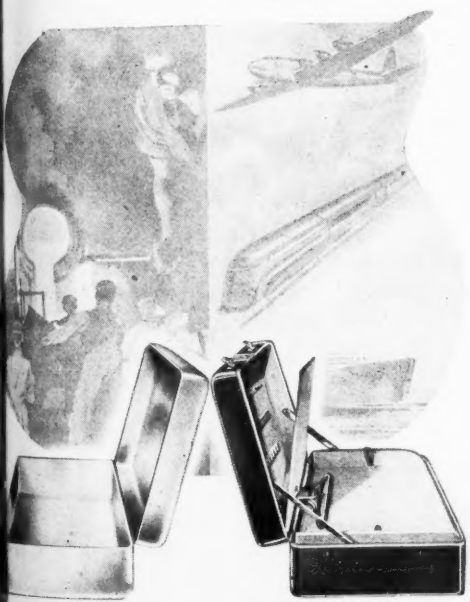

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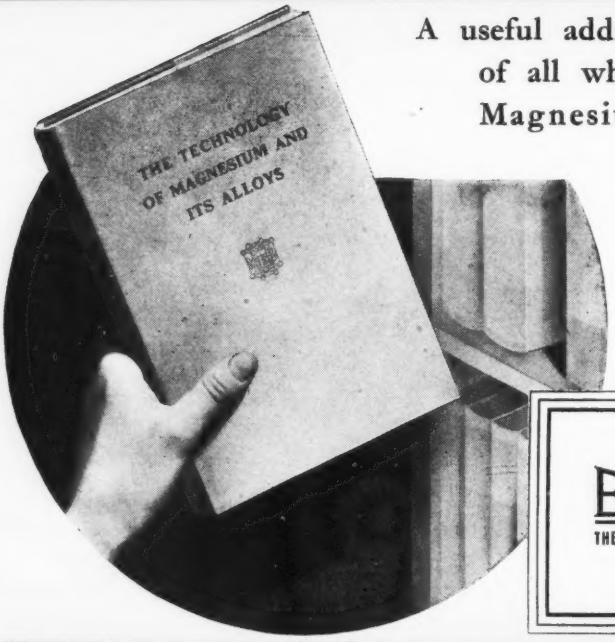

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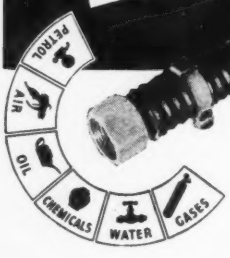

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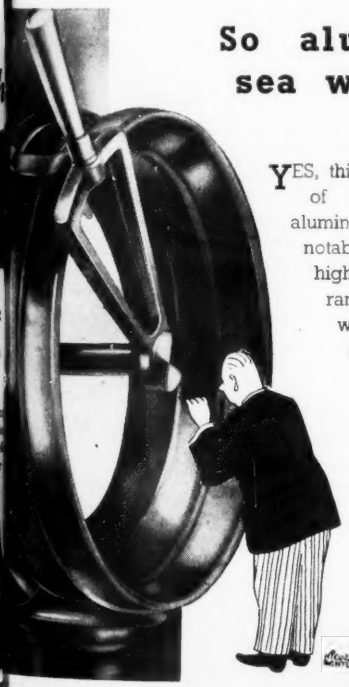

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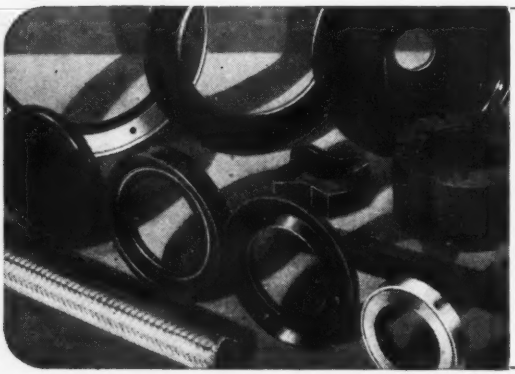

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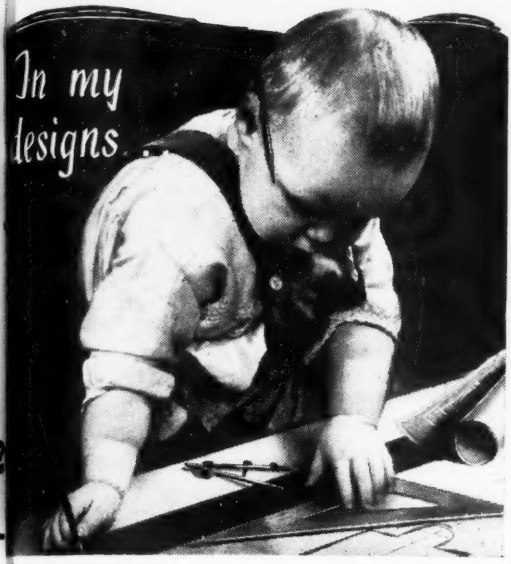

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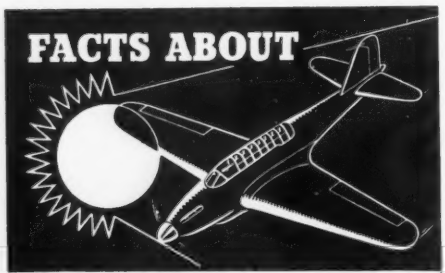

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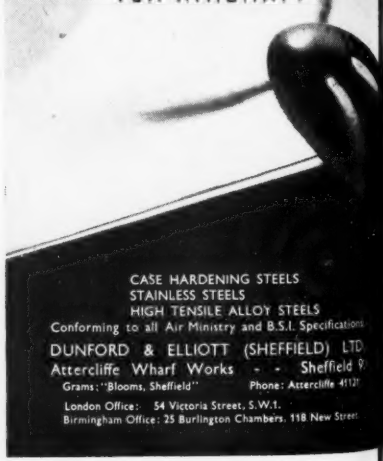

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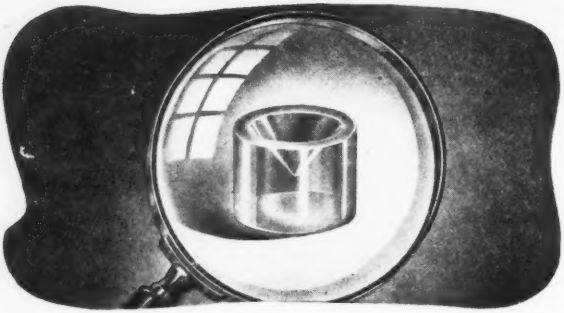

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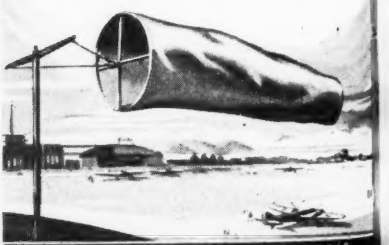

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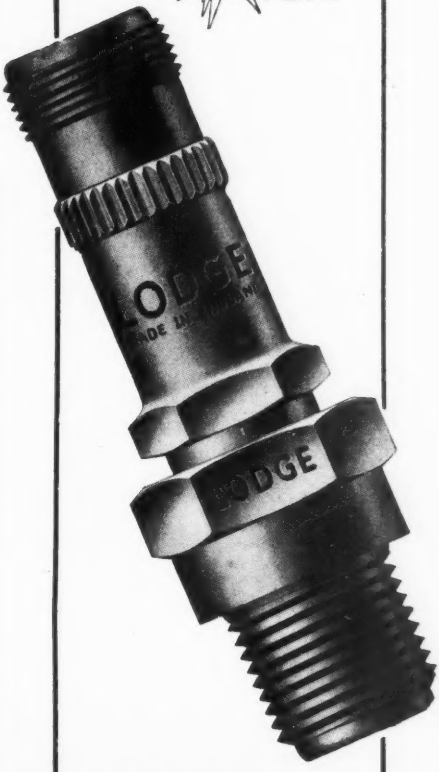

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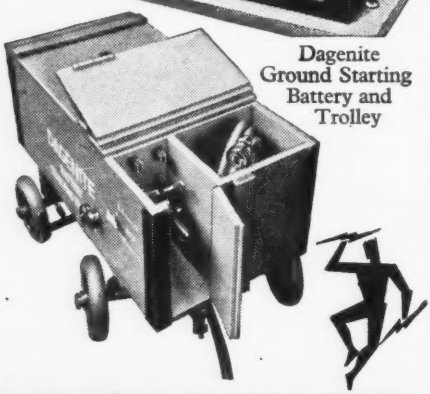

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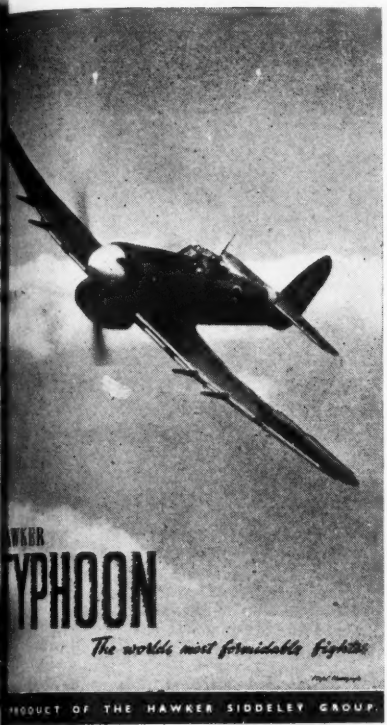
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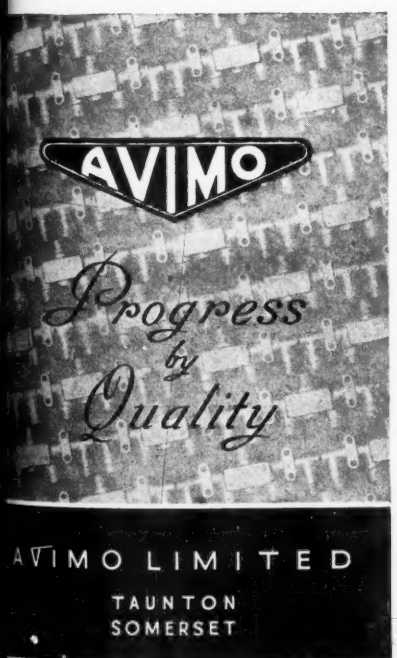
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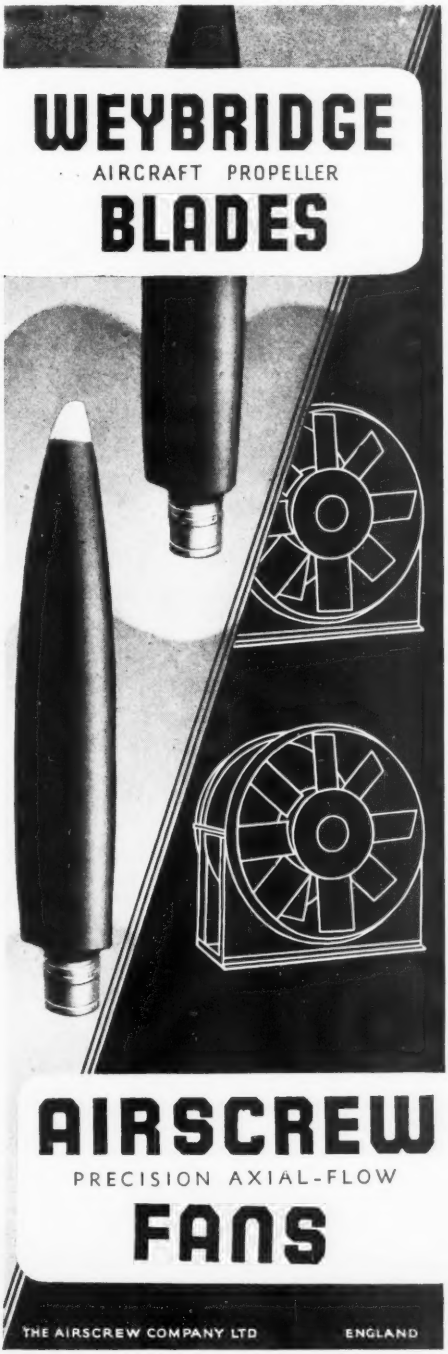
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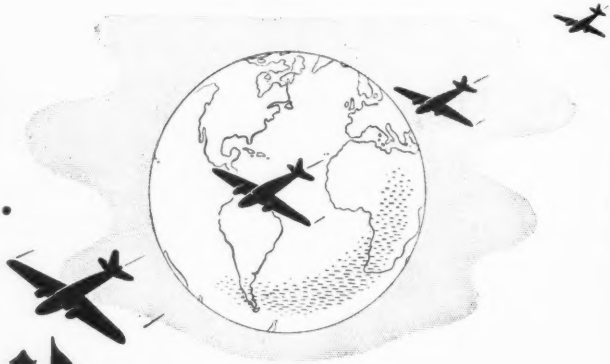

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THE JOURNAL OF THE ROYAL AERONAUTICAL SOCIETY *was founded in* 1897 *in succession to the* ANNUAL REPORTS.

For the opinions expressed in Papers that are signed or initialled the authors alone are responsible. None of the papers or paragraphs must be taken as expressing the opinion of the Council of the Royal Aeronautical Society unless such is definitely stated to be the case.

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Vibrations in Aircraft II. R. G. Manley.
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Principles Involved in Punching. A. J. Schroeder.

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MONTHLY NOTICES

MARCH, 1944.

Annual General Meeting.

Below is printed formal notice of the Annual General Meeting. On account of the shortage of paper further notice will not be sent to members.

ANNUAL GENERAL MEETING.

NOTICE IS HEREBY GIVEN that the Annual General Meeting of the Royal Aeronautical Society with which is incorporated the Institution of Aeronautical Engineers will be held on Monday, March 27th, 1944, at 6 p.m., in the Offices of the Society, at 4, Hamilton Place, London, W.1.

AGENDA.

1. To read the Notice convening the Meeting.
2. To receive and deliberate upon the Report of the Council on the state of the Society and the Balance Sheets of Aerial Science, Limited, and Aeronautical Trusts, Limited, for the year ended December 31st, 1943.
3. To receive the nominations for Council for the years 1944-1945.
4. To announce the list of Fellows elected by the Council in accordance with Rule 4.
5. To appoint the Auditors for the ensuing year for Aerial Science, Limited, and Aeronautical Trusts, Limited.
6. Any other business.

By Order of the Council,

J. LAURENCE PRITCHARD,

Secretary.

Message from the Secretary.

The Secretary makes a special appeal to members to be a little indulgent during the next few months if there are delays in answering letters. The work of the Society has increased heavily, the staff is less than half what it was at the beginning of the war and is working at high pressure.

Lecture.

The following lecture has been arranged to be held at 5.30 p.m. in the Lecture Hall of the Institution of Mechanical Engineers, by kind permission of the Council of the Institution:—

March 9th, 1944.—" Aerodynamic Features of German Aircraft," by Mr. M. B. Morgan, M.A., and Mr. R. Smelt, B.A.

Light refreshments will be served before the meeting.

Graduates' and Students' Section.

The Annual General Meeting of the Graduates' and Students' Section will be held in the Library at 4, Hamilton Place, W.1, on Thursday, March 30th, 1944, at 7.30 p.m.

AGENDA.

1. To consider a revised draft of the Rules of the Section.
2. To receive the Report of the Secretary on the affairs of the Section.
3. To elect Officers and Committee for the Session 1944-1945.
4. To receive proposals for the future activities of the Section.
5. To consider any other business.

Notification of questions to be raised under Item 5 should, if possible, reach the Honorary Secretary, Mr. E. J. Archbold, at 27, North View, Eastcote, Pinner, Middlesex, by 23rd March.

The following lectures have been arranged by the Graduates' and Students' Section. They will be delivered in the Library, at 4, Hamilton Place, W.1, at 7.30 p.m.

Thursday, April 6th.—Mr. P. G. Masefield, M.A., A.F.R.Ae.S., on " American Aircraft."

Wednesday, April 19th.—Mr. A. J. Penn on " The Design and Operation of Superchargers."

Thursday, May 11th.—Mr. J. A. Churchill on " Power Plant Installation and Design."

Graduates and Students are also invited by the Graduates' Branch of the Institution of Automobile Engineers to the following meetings:—

Sunday, March 12th.—Paper by Mr. C. L. James on " Torsion Bar Springs for Automobile Suspension."

Sunday, April 16th.—Informal Talk by C. Kimber on " The Sports Car—Its Past and Future."

The above will be held at 3.0 p.m. at the Institution of Automobile Engineers, 12, Hobart Place, S.W.1.

Graduates' and Students' Visits.

It is regretted that the visits arranged to the De Havilland Assembly Plant are postponed for the time being. It is hoped, however, that later on visits may be arranged for those who have not been able to attend so far.

Branch Lectures.

The following Lectures have been arranged before the Luton Branch:—

Wednesday, 1st March, 1944, at 7.15 p.m.—Lecture on " Superchargers," by A. J. Penn, A.M.I.Mech.E., Supercharger Development Engineer, D. Napier and Son, Ltd.

Wednesday, 5th April, 1944, at 7.15 p.m.—Lecture on " Air Transport," by Dr. Roxbee Cox, B.Sc., D.I.C., F.R.Ae.S., Vice-President of the Royal Aeronautical Society.

New Branches.

The Council have approved the formation of two new Branches, one in Derby and the other in South Africa. The addresses of the Temporary Honorary Secretaries are as follows and those interested should communicate with them:—

Major G. A. Mann, A.F.R.Ae.S., 24, Ostend Road, Germiston, South Africa.

J. L. Batchelor, A.R.Ae.S., Department of Mechanical Engineering, Derby Technical College, Derby.

Acknowledgments.

The Council would like to acknowledge their grateful thanks to the following members for donations to the Endowment Fund:—

Warrant Officer J. V. Saunders, G.M., Associate Fellow.
Mr. D. K. Saunders, Student.

The Council also acknowledge their grateful thanks for the gift of books for the Library from Mr. C. G. Grey, Founder Member, including the rare "History of the Charvolant or Kite Carriage" (1851), and also a copy of Lieut.-General Golovine's "Air Strategy" (now out of print) presented by the Author.

Election of Members.

The following members have recently been elected:—

Associate Fellows.—Stanley George Custance, Iestyn Griffith Davies, Cyril Gibson, Bertram Roland Grantham (from Graduate), David Anthony Cardnell Harper (from Graduate), Roy Eugene Montgomery Lloyd (from Associate), Robert Thomson, Edwin Colby Walton.

Associates.—Frederick Albert Baker, Frederick Thomas Bevan, Francis Charles Bradley, Thomas William Brooke-Smith, Thomas George Elliott, John Robert Coulson, Clifford Fenn, Edward Ernest Gardiner, Thomas Frank King, Stanley Douglas McDonald, William Frederick Forrest Martin-Hurst, Leslie Thomas Palmer, George Albert Pickett, Reginald Albert Pulling, William Sidney Smith-Palmer, John Brown Stoneman.

Graduates.—Peter Eugene Bish (from Student), Arthur Ronald Butler, Ernest George Collins, George Gilbert Gale (from Student), David Jeffrey Goman (from Student), Eric Martin Goodger (from Student), Clarence Charles Greensmith, John Charles Hamon, Robert George Irons, Alfred Ernest Banjamin Kearsey, Ernest Frederick Needham (from Student), Arthur Newby, Richard Thomas Courtenay Satterford, Gordon Heatherton Vokes (from Student).

Students.—Kenneth George Attkins, Kenneth Rex Barnett, Jeremiah Cashman, George Herbert Cooper, W. Cunningham, Edward Melbourne Dallimore, Vivian Woodland Erlebach, John Gregory, Derek Hanchett-Stamford, Ronald William Hayden, Leslie Arthur Holland, Donald Jackson, Charles Neville Jones, Eric Ernest Labram, Harold Barry Lee, Derek Stanton Lubell, Raoul Gery Edward Mallin, Radhesh Prasad Naudi Majumdar, Cyril George Newman, John Harold Richard Oakley, George Robert Prime, Clement Barry Redgate, Gordon William Richardson, William Bernard Richardson, John Henry Risdon, Leslie John Roper, Bob Bakhshi Singh Salaria, John Geoffrey Shaw, Ronald Silverblatt, Robert Hugh Williams, Edward Wray, Peter Yule.

Companions.—Alexander Napier Chinnery-Haldane, David Solomon Erulkar, William Edgar Waudby Granger, Yehuda Kritchevsky, Philip G. Marr, Alan Edward Slater.

Associate Fellowship Examination, May, 1944.

Intending Candidates for the Associate Fellowship Examination in May, 1944, are reminded that their entries must be in by March 31st, 1944.

Associate Fellowship Examinations, December, 1943.

The following were successful in the Associate Fellowship Examinations held in London in December, 1943:—

Allan, R., Strength of Aeronautical Materials; Angel, S. M., Pure Mathematics; Ayers, K. B., Applied Mathematics (1st Place, tie); Barnden, R. G., Applied Mathematics, Design (Aero Engines), Theory of Machines; Barnes, F., Pure Mathematics (1st Place, tie), Strength of Aeronautical Materials, Aircraft Design; Brown, R. F., Applied Mathematics, Aerodynamics, Aircraft Design (Baden-Powell Memorial Prize); Butler, F. B., Applied Mathematics, Design (Aero Engines), Theory of Machines; Button, B. R., Applied Mathematics; Chivers, A. J., Pure Mathematics, Strength of Aeronautical Materials (1st Place); Cooke, R. M., Pure Mathematics; Cosier, P. H., Pure Mathematics; Davidson, J. W., Pure Mathematics; Dryland, P. W., Applied Mathematics, Aerodynamics, Aircraft Design; Edwards, B., Applied Mathematics, Design (Aero Engines); Evans, J. D., Applied Mathematics; Firmin, J. C., Applied Mathematics, Theory of Machines, Design (Aero Engines); Fletcher, G. L., Theory of Machines; Goodenough, G. W. C., Aircraft Design; Groen, D. J., Applied Mathematics, Aerodynamics, Theory of I.C. Engines; Knowles, A. S., Applied Mathematics, Aerodynamics, Theory of I.C. Engines (1st Place); Lipman, S., Air Transport, Theory of Machines; Martin, P., Applied Mathematics, Aircraft Design; Miller, A. D., Applied Mathematics, Navigation, Aerodynamics; Mugford, M. D., Applied Mathematics, Design (Aero Engines), Theory of Machines; Obee, K. R., Strength of Aeronautical Materials; Paton, D. W., Pure Mathematics, Theory of Machines, Strength of Aeronautical Materials; Prewitt, W. C., Applied Mathematics; Pringle, B., Aerodynamics, Aircraft Materials (1st Place); Roland, L. D., Pure Mathematics, Theory of Machines, Theory of I.C. Engines; Seal, A., Applied Mathematics, Theory of Machines (1st Place), Design (Aero Engines) (1st Place); Simpson, E., Pure Mathematics; Thirkettle, J. R., Pure Mathematics; Thompson, W., Pure Mathematics; Wallis, J., Design (Aero Engines); Walters, H. J., Applied Mathematics; Ward, Miss M. T. P., Design (Aero Engines); Warren, S., Applied Mathematics, Theory of Machines, Design (Aero Engines); Wels, T. A., Aircraft Design; Wilson, L. D., Aircraft Materials.

Baden-Powell Memorial Prize.

Mr. R. F. Brown was considered the best candidate in the December, 1943, Associate Fellowship Examinations, and is therefore awarded the Baden-Powell Memorial Prize.

Income Tax.

In response to numerous inquiries with regard to a rebate on Income Tax for their subscriptions, the following is a copy of a letter received from the Principal Inspector of Taxes:—

"Ref. H.R.S. 34/C.I. 4420/63.

Dear Sir,—Further to your interview with Mr. Stonely at this office on the 19th July, I am now in a position to inform you that the Board of Inland Revenue will not raise objection to the allowance as an expense for Income Tax purposes of annual subscriptions paid by members who are:—

(i) Assessable under Schedule D of the Income Tax Acts in respect of professional or trading profits, subject to the decision of the Commissioners who make the assessment that such subscriptions are sufficiently closely related to the business carried on; or

(ii) Assessable under Schedule E in those cases only in which continual membership of the Society is an essential condition of the terms of appointment.

Yours faithfully,

(Signed) GEO. WILCOCK,

Principal Inspector of Taxes."

Additions to the Library.

The following books have been added to the Library during February:—

Pamphlets in italics with location reference following in brackets.

Books marked * or ** may not be taken out on loan.

A.c.15.—Thermodynamics Applied to Heat Engines. E. H. Lewitt. Sir Isaac Pitman and Sons. 1943. 25/-. (3rd Ed.)

B.a.309.—American War Planes in Action. S. E. Veale. Pilot Press, Ltd. 1944. 5/-.

C.d.149.—British Airships: Past, Present and Future. George Whale. The Bodley Head. 1919.

E.b.96.—The Analysis of Engineering Structures. A. J. S. Pippard and J. F. Baker. Edward Arnold. 1944. 30/-. (2nd Ed.)

E.g.7.—Aircraft Hydraulics Simplified. David Vine. George Newnes, Ltd. 1943. 3/6.

EE.h.11.—*To New York in Five Hours? (Future of the Jet-Propelled Plane.) G. Geoffrey Smith. (Article in "The Listener," Jan. 20, 1944.)* (Y.7.b.6.)

G.e.A.89.—*Ultimate Strength of Duralumin Compression Members. Leslie P. Dudley. (Article in "Light Metals," Dec., 1941.)* (Y.13.c.A.)

G.e.A.90.—*Effect of Projectiles on Strong Light Alloy Plates. (Article, unsigned, backing on above.)* (Y.13.c.A.)

H.b.87.—L'Aviation et le Désarmement. Roland Bechoff. Les Editions Internationales, Paris. 1933. Frs. 20.

L.d.100.—Teach Yourself Astro Navigation. "Kaspar" (F./Lt. S. R. Millard). English Universities Press. 1944. 3/-.

L.e.12.—The Observer's Handbook on Maps, Charts and Projections. W. Alexander and W. J. D. Allan. Allen and Unwin. 1940.

*L.h.60.—The Universal Atlas. W. and A. K. Johnston. W. and G. Foyle, Ltd. 1940. 10/6.

**L.j.91.—Reindeer Lake and Churchill River Photographic Operations. (Official report; typescript with photos.) Royal Canadian Air Force Station, Manitoba. 1924.

*L.k.40.—Handbuch der normaien und pathologischen Physiologie. Vol. 15, Part 2: Arbeitsphysiologie II. Edited by Bethe, Von Bergmann, Embden and Ellinger. Julius Springer, Berlin. 1931.

*P.c.39.—Patent Abstracts: Aeronautics, 1899-1914. Rayner and Co., Patent Agents. 1917.

**R.b.251. The History of the Charvolant or Kite Carriage. G. Pocock. Longman, Brown and Co. 1851.

R.e.52.—The Romance of Aircraft. L. Yard Smith. Grant Richards. 1919.

R.f.93.—*Almanach* (1936) *de l'Aviation Belge*. 1936. (Y.11.14.20.)

R.f.94.—Four Miles South of Kitty Hawk. Warren Macarthur Corporation. 1943.

S.a.137.—War Facts and Figures. British Dominions General Insurance Co. Undated (about 1917).

S.a.138.—Textbook of Naval Aeronautics. Henry Woodhouse. T. Werner Laurie. 1918.

S.b.133.—The Men Who Fly. Hector Hawton. Nelson and Sons. 1944. 5/-.

S.b.134.—To-day with the R.A.F. "Wing Adjutant" (Major W. T. Blake). Cassell and Co. 1939. 6/-.

S.c.10.—The United States in the Air. Mason M. Patrick. Doubleday, Doran and Co. (New York). 1928.

S.d.85.—*Douhet, Mitchell, Seversky: Theories of Air Warfare. Ed. P. Warner. Princeton University Press.* 1943. (*Reprint of Chap.* 20: "*Makers of Modern Strategy.*") (PS.2/13.)

*S.d.86.—Air Strategy. Lt.-Gen. N. N. Golovine. Gale and Polden. 1939. 7/6.

S.d.87.—La. Guerre de l'Air. Gen. G. Douhet. "Les Ailes," Paris. 1932.

S.e.78.—Triumph Over Tunisia. Wing-Com. T. H. Wisdom. Allen and Unwin. 1944 8/6.

*T.a.110.—La Vie des Hommes Illustres de l'Aviation. Jacques Mortane. Roche d'Estrez, Paris. 1926.

T.a.111.—*Sir Frederick Henry Royce and His Work. G. Geoffrey Smith. (Article in M.O.I. publication "War in Pictures.")* 1944. (Y.5.R.)

TT.a.46.—The Plane Truth. M. J. B. Stoker. Duckworth. 1938. (Humorous.)

TT.b.19.—Ballads of the Flying Corps. G. R. Samways. McBride, Nash and Co. 1917.

*X.b.147.—The British Dominions Year Book. Eagle, Star and British Dominions Insurance Co. 1921.

*X.b.148.—Armaments Year Book, 1929-1930. League of Nations. 1930.

*X.e.52.—Who's Who in American Aeronautics. Ed. by Lester D. Gardner. Aviation Publishing Corporation, New York. (3rd Ed.) 1928.

*X.e.53.—"The Aeroplane" Directory of the Aviation and Allied Industries. Temple Press, Ltd. 1937. 10/6. (2nd Ed.)

*UU.c.—*National Advisory Committee for Aeronautics*:—

Technical Memoranda:—

No. 1053. Turbulent Friction in the Boundary Layer of a Flat Plate in a Two-Dimensional Compressible Flow at High Speeds. F. Frankl and V. Voishel. (C.A.H.I. Trans. No. 321, 1937.)

No. 1055. Determination of the Stresses Produced by the Landing Impact in the Bulkheads of a Seaplane Bottom. V. M. Darevsky. (C.A.H.I. Trans. No. 449, 1939.)

No. 1056. Piston Ring Pressure Distribution. M. Kuhn. (A.T.Z., Feb. 10, 1942.)

No. 1059. An Experimental Investigation of the Flow of Air in a Flat Broadening Channel. (C.A.H.I. Trans. No. 137, 1926.)

*V.7/26.—Transactions of the Institution of Naval Architects. Vol. 85. 1943.

Also the following publications in Russian :—

T.a.109.—Life of Nicolas Egorovitch Joukowsky. V. V. Golubiev. Central Aero-Hydrodynamical Institute. 1941.

C.d.148.—Principles of Dirigible Construction. A. H. Vachmintsev. State Press for National Defence Industry. 1940.

J. LAURENCE PRITCHARD, *Secretary and Editor.*

ROCKET-WING-BOMB AND ROCKET-TORPEDO.

By Zbigniew Leliwa-Krzywoblocki (Dipl.-Ing.).

Introduction.

For the problem of bombing from a distance we may use either ordinary wing-bombs or wing-bombs acting by propulsion (*e.g.*, rocket propulsion). The uses of such bombs have been thoroughly discussed by Rougeron in his well-known book " L'Aviation de Bombardement " (1).

Speaking generally, rocket propulsion may be applied to the following projectiles :—

(*a*) Normal Rocket-Bombs.
(*b*) Rocket Wing-Bombs (3).
(*c*) Rocket Torpedoes.

The possibility of using rockets for this purpose depends upon the solution of such constructional problems as :—

(*a*) Instruments for the Stability of Flight.
(*b*) Propulsion (*e.g.*, Petrol).
(*c*) Large Powder-Rockets.

This article aims at giving an approximate calculation of the range of wing-bombs and rocket-wing-bombs, and discusses whether the use of rocket-propulsion is likely to be advantageous.

Symbols Employed.

R = force of the reaction.
m = mass of gases burnt in 1 sec.
am = joint mass of gases burnt and air aspired in 1 sec.
w = velocity of burnt gases relative to the walls of the rocket nozzle.
v = velocity of the rocket relative to the air (the latter being assumed to be stationary relative to the earth).
L_g = whole energy of burnt gases.
η = degree of the " exterior " efficiency of the rocket.
w' = velocity of the mixture of burnt gases and aspired air relative to the walls of the rocket nozzle.
η' = degree of " interior " efficiency of the multiple Melot's nozzle, dependent upon losses during mixing.
t = time.
ϵ = optimum lift/drag ratio of wing-bomb (" finess ").
α = angle of glide-path of wing-bomb.
h = height of flight.
p = range of wing-bomb (on level).
β = angle.
W = weight of wing-bomb.
W_R = weight of working material of rocket.
D = drag of wing-bomb.
L = lift of wing-bomb.
C_L = lift coefficient.
C_D = drag coefficient.
ρ = air density.
A = wing area.

M = mass of working material.
s_1 = distance on level traversed by wing-bomb while rocket is burning.
s_2 = distance on level traversed by wing-bomb when rocket has burned out and during gliding flight.
g = gravity.

In Sänger's formulæ :—

G_0 = weight of rocket-torpedo at the beginning of upward flight.
G = weight of rocket-torpedo at the end of upward flight.
k_1 = coefficient.
v_0 = initial speed of rocket-torpedo in vicinity of earth (*e.g.*, imparted by catapult).
v = speed of rocket-torpedo at the end of upward flight.
ζ = angle of upward flight.
t = time of upward flight.
s = distance on course traversed by rocket-torpedo during upward flight.
s_1 = distance on level traversed by rocket-torpedo during upward flight.
h = height at the end of upward flight.
$\epsilon = C_D / C_L$.
$v_m = (v_0 + v_1)/2$.

1. The Elementary Formulæ of Rocket Propulsion.

First of all, let us briefly resume the elementary formulæ of Rocket Propulsion (2).

(*a*) The simple rocket, without aspiration of air.

From the equation :—

$$Rt = mw \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

for

$$t = 1 \text{ sec.} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

we derive the force of the reaction :—

$$R = mw \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

The total energy of gases :—

$$L_g = Rv + (m/2)(w - v)^2 \quad . \quad . \quad . \quad . \quad (4)$$

On the right side of the equation, the first term represents the useful power, the second one the losses.

$$\eta = \frac{Rv}{L_g} = \frac{2wv}{w^2 + v^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

when

$$v = w \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

we have " maximum " of

$$\eta = 1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

when

$$v \lessgtr w \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

we have

$$\eta < 1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

The magnitude of the reactive force does not depend upon whether or not the rocket is in motion, but merely upon the velocity of gases " w." The magnitude of " η " is dependent upon the rocket speed " v " and also on the velocity of gases " w." When :—

$$v = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

$$\eta = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

(*b*) The rocket aspiring outside air (Melot's multiple nozzle) in motion. It is assumed that the degree of "interior" efficiency of Melot's multiple nozzle is equal 1, and that there are no mixing losses.

$$\eta i = 1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

$$R = mw' + m\,(a-1)\,(w'-v) \quad . \quad . \quad . \quad . \quad (13)$$

$$L_g = Rv + (am/2)\,(w'-v)^2 \quad . \quad . \quad . \quad . \quad (14)$$

$$= \frac{Rv}{L_g} = \frac{2v\,(w'-v+v/a)}{w'^2 - v^2 + 2v^2/a} \quad . \quad . \quad . \quad . \quad (15)$$

(*c*) The rocket aspiring outside air (Melot's multiple nozzle) at rest. Assuming as before that:—

$$\eta i = 1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

we have:—

$$R = mw' + m\,(a-1)\,w' = maw' \quad . \quad . \quad . \quad . \quad (16)$$

$$L_g = \frac{am}{2}\,w'^2 \quad . \quad . \quad . \quad . \quad . \quad (17)$$

$$\eta = Rv^2/L_g = 0 \quad . \quad . \quad . \quad . \quad . \quad (18)$$

2. Normal Rocket-Bomb.

The object of applying rocket propulsion to normal bombs is to increase their penetrating force. Rougeron (1) gives the results of calculations of such bombs, which are extremely interesting. Here, we need only say that there are cases in which these bombs can be very useful.

3. Rocket Wing-Bombs.

(*a*) *Wing-Bomb.*—In the first place, we will calculate the range of a wing-bomb without propulsion. This bomb is assumed to have its explosive charge in front and its stabilising instruments at the back. The accepted basis is as under:—

(i) Optimum lift/drag ratio must be fairly high, because the wing-bomb must be given very high aerodynamical qualities.

$$\varepsilon = 10 \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

(ii) The energy imparted to the wing-bomb by the aircraft in flight is ignored.

(iii) According to (ii) the range of the wing-bomb, calculated from the moment of its release, is not dependent on its weight, but only on optimum lift-drag ratio and the height of flight.

(iv) The glide-path is a straight line inclined to the horizontal at the angle:—

$$tg\,\alpha = 1/\varepsilon = 1/10 \quad . \quad . \quad . \quad . \quad . \quad (20)$$

We have:—

$$p = h \cot \alpha = 10h \quad . \quad . \quad . \quad . \quad . \quad (21)$$

Table I gives the value of p for various heights.

Table I.

h (metres) ...	2,000	4,000	6,000	8,000	10,000
h (feet) ...	6,580	13,160	19,740	26,300	32,900
p (km.) ...	20.00	40.00	60.00	80.00	100.00
p (feet) ...	65,800	131,600	197,400	263,200	329,000
p (miles) ...	12.45	24.90	37.35	49.80	62.25

Represented graphically, the function:—

$$p = f(h) \quad . \quad . \quad . \quad . \quad . \quad . \quad (22)$$

is a straight line inclined to the horizontal at the angle :—

$$\tan \beta = 10 \quad . \quad . \quad . \quad . \quad . \quad . \quad (23)$$

(*b*) *Rocket Wing-Bomb.*—It is self-evident that such a bomb has its explosive charge in front, stabilising instruments in the middle, and rocket-motor behind. In the case of powder-rockets, this would consist of a feeding mechanism, similar to that of a machine-gun. Rockets could also be arranged in rings and ignited one after another. Table II gives speeds "*w*" for various materials, according to (4).

TABLE II.

Material.	Theoretical Speed.	Real Speed (measured).
1. Normal powder of "Coston" ship rocket.	2,350 m./sec.	1,600 m./sec.
	7,720 ft./sec.	5,270 ft./sec.
2. Pistol powder No. 3, Dupont Powder Co.	2,860 m./sec.	2,290 m./sec.
	9,400 ft./sec.	7,550 ft./sec.
3. Smokeless powder, "Infallible" Hercules Powder Co.	3,220 m./sec.	2,434 m./sec.
	10,600 ft./sec.	8,000 ft./sec.
4. Petrol.	2,190 m./sec.	1,700 m./sec.
	7,200 ft./sec.	5,590 ft./sec.
5. Mixture of hydrogen and oxygen.	4,470 m./sec.	4,000 m./sec.
	14,740 ft./sec.	13,180 ft./sec.

The air density is taken as being that specified by the Commission Internationale de Navigation Aerienne (C.I.N.A.) (4).

TABLE III.

Height.		Units of Atmospheric Density, according to C.I.N.A. Standard.	
m.	ft.	kg./m.^{3}	lb./cu. ft.
0	0	1.2249	0.0767
2,000	6,580	1.0064	0.0625
4,000	13,160	0.8191	0.0510
6,000	19,740	0.6597	0.0412
8,000	26,320	0.5252	0.0327
10,000	32,900	0.4127	0.0257

ACCEPTED BASIS.

(i) We will proceed to calculate bombs weighing 100 kg. (221 lb.), 250 kg. (551 lb.), 500 kg. (1,105 lb.), and 1,000 kg. (2,210 lb.).

(ii) Wing area is taken as :—

1 m.^{2} (10.76 sq. ft.),
2.5 m.^{2} (26.90 sq. ft.),
5.0 m.^{2} (53.80 sq. ft.),
10.0 m.^{2} (107.60 sq. ft.),

respectively.

(iii) According to (i) and (ii), we assume the same wing-loading for all types of wing-bomb, *i.e.*, 100 kg./m.^{2} (20.4 lb./sq. ft.).

(iv) The weight of working material for rocket propulsion is equal to 0.25 weight of the wing-bomb.

(v) The oxygen or air necessary for combustion (*e.g.*, of petrol) is included in the weight of working material. Air is not taken from outside.

(vi) The optimum lift-drag ratio of the wing-bomb is 10.

(vii) No account is taken of diminution in the weight of the rocket wing-bomb during flight, either as affecting trajectory or speed.

(viii) While the rocket is burning, the line of flight is horizontal and the motion of the wing-bomb is uniform.

(ix) The energy imparted to the rocket wing-bomb by the aircraft in flight is neglected.

(x) Once the working material of the rockets is consumed, the glide-path is a straight line inclined to the horizontal at an angle depending upon optimum lift/drag ratio.

(xi) For all bombs we assume that :—

$$C_D = 0.1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (24)$$

$$C_L = 1.0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (25)$$

The order of calculation is :—

$$WR = W/4 \quad . \quad . \quad . \quad . \quad . \quad . \quad (26)$$

$$R = D = L/10 = W/10 \quad . \quad . \quad . \quad . \quad . \quad (27)$$

$$t = Mw/R = Ww/4gR \cong 0.254\, w \quad . \quad . \quad . \quad . \quad (28)$$

Time of burning of rockets is solely dependent upon the type of working material.

From the equations :—

$$W = L = C_L \frac{\rho}{2} A v^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (29)$$

or

$$R = D = C_D \frac{\rho}{2} A v^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (30)$$

we calculate the speed :—

$$v = \sqrt{(2W/C_L \rho A)} \quad . \quad . \quad . \quad . \quad . \quad . \quad (31)$$

On the assumption that wing loading is constant for all bombs, the speed v is not dependent either on weight of bombs or on kind of working material, but only upon height of flight.

$$s_1 = vt \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (32)$$

In the case under consideration, the value of s_1 depends only on height of flight and on type of working material.

Gliding flight :—

$$s_2 = 10\, h \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (33)$$

$$p = s_1 + s_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (34)$$

Consequently, the value of p depends on the height of flight, the type of working material, and the optimum lift/drag ratio of the rocket wing-bomb.

Results of calculations are given in Tables and in Fig. 1.

The functions :—

$$p = f(h) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (35)$$

are now curved lines.

TABLE IV.

Weight of Bomb. W		Weight of Working Material. WR		Drag or Reactive Force. $D-R$	
kg.	lb.	kg.	lb.	kg.	lb.
100	221	25.0	55.2	10	22.1
250	552	62.5	138.0	25	55.2
500	1,105	125.0	276.2	50	110.5
1,000	2,210	250.0	552.5	100	221.0

TABLE V.

Type of Working Material (from Table II).	Time of Combustion. t/sec.
1	407
2	584
3	619
4	432
5	1,010

TABLE VI.

Height: km. ...	2,000	4,000	6,000	8,000	10,000
(h) ft.	6,580	13,160	19,740	26,320	32,900
Speed: m./sec...	14.0	15.6	17.2	19.5	22.0
(v) ft./sec. ...	46.1	51.4	56.8	64.2	72.2

TABLE VII.

$s_1 = f(v, t)$ for $W/A = 20.4$ lb./sq. ft.

t/sec. / v							
m./sec	ft./sec.	407	584	619	432	1,010	
14.0	46.1	5,700	8,180	8,660	6,040	14,140	m.
		18,800	27,000	28,500	19,900	46,500	ft.
15.6	51.4	6,370	9,110	9,600	6,740	15,920	m.
		21,000	30,000	31,600	22,200	52,400	ft.
17.2	56.8	7,000	10,050	10,320	7,420	17,380	m.
		23,100	33,000	33,950	24,500	57,100	ft.
19.5	64.2	7,950	11,400	12,080	8,420	19,740	m.
		26,200	37,520	39,800	27,750	65,000	ft.
22.0	72.2	8,940	12,860	13,600	9,500	22,200	m.
		29,500	42,450	44,850	31,300	73,100	ft.

TABLE VIII.

$p = f$ (v, height, material) for $W/A = 20.4$ lb./sq. ft.

Working Material from Table II. / Height of Flight.							
km.	ft.	1	2	3	4	5	
2,000	6,580	25.70	28.18	28.66	26.04	34.14	km.
		16.00	17.50	17.80	16.20	21.20	miles.
4,000	13,160	46.37	49.11	49.60	46.74	55.92	km.
		28.80	30.60	30.90	29.10	34.70	miles.
6,000	19,740	67.00	70.05	70.32	67.42	77.38	km.
		41.70	43.00	43.80	42.00	48.10	miles.
8,000	26,320	87.95	91.40	92.08	88.42	99.74	km.
		54.80	56.80	57.40	55.00	62.00	miles.
10,000	32,900	108.94	112.86	113.60	109.50	112.20	km.
		67.80	70.20	71.00	68.00	76.00	miles.

Another factor to consider is the influence of wing-loading. Quadrupling the wing-loading will double the speed (v) and distance (s_1) (31) and (32).

Table IX gives values of p for:—

$$W/A = 400 \text{ kg./m.}^2 = 81.6 \text{ lb./sq. ft.} \quad . \quad . \quad . \quad (35$$

TABLE IX.

$p = f$ (height, material) for $W/A = 81.6$ lb./sq. ft.

Working Material from Table II.							
Height of Flight.							
km.	ft.	1	2	3	4	5	
2,000	6,580	31.40	36.36	37·32	32.08	48.28	km.
		19.50	22.80	23.20	20.00	30.00	miles.
4,000	13,160	52.74	58.22	59.20	53.48	71.84	km.
		32.75	36.30	36.90	33.25	44.70	miles.
6,000	19,740	74.00	80.10	80.64	74.84	94.76	km.
		46.20	49.85	50.00	46.50	58.80	miles.
8,000	26,320	95.90	102.80	104.16	96.84	119.48	km.
		59.70	64.00	64.90	60.00	74.60	miles.
10,000	32,900	117.88	125.72	127.20	119.00	144.40	km.
		73.40	77.85	79.00	74.00	90.00	miles.

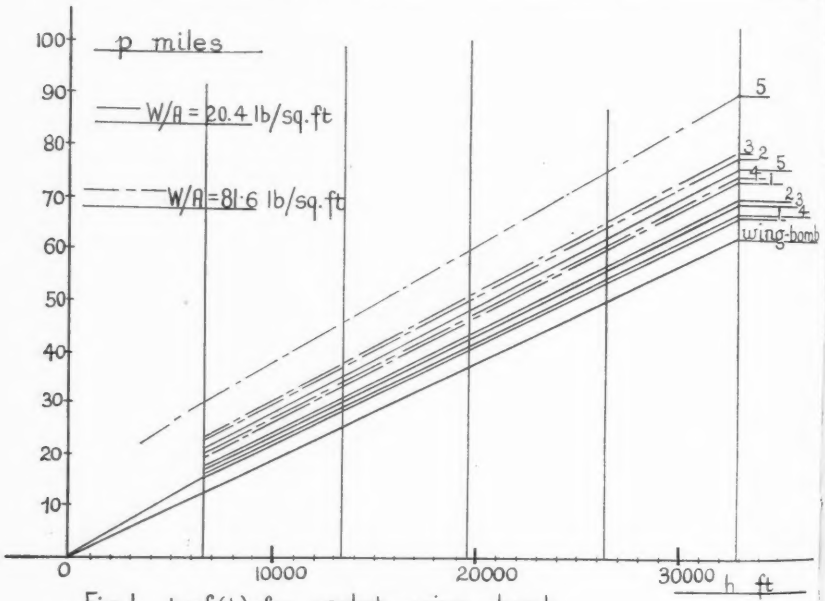

Fig 1. $p = f(h)$ for rocket-wing-bomb.

From these tables and from Fig. 1, the following conclusions may be drawn:—

(*a*) The influence of rocket-propulsion in increasing the range of a wing-bomb, as compared with a similar bomb without propulsion, is greater at low altitudes than at higher ones.

(*b*) From a general point of view, height has more influence than rocket-propulsion on the range of a wing-bomb.

(*c*) Following from (*b*), the influence of optimum lift-drag ratio and aspect ratio on the range of a wing-bomb is very considerable.

(*d*) The type of working material of rockets has greater influence at low altitudes, where it is better to use stronger materials. At greater heights the type of material is less important.

(*e*) The use of rocket-propulsion for wing-bombs may be very advantageous when releasing bombs at low altitudes, which gives greater accuracy of aim. In this case, stronger materials should be used.

(*f*) The influence of wing loading is very important. Small wings of high aspect ratio should be used.

(*g*) Although there are many technical difficulties to be solved in the construction of rocket motors and in the manufacture of large powder rockets, it seems certain that, speaking generally, the adoption of rocket propulsion for wing-bombs may be advantageous.

(*h*) The use of wing-bombs for attacking extensive targets (*e.g.*, cities) may be advantageous; hence the solution of constructional problems, such as that of the instruments for stability of flight, is of great practical importance. In fact, scientists are working upon them in several countries to-day.

4. The Rocket-Torpedo.

The rocket-torpedo is similar to the rocket wing-bomb, with the difference that the former is shot from the ground by means of some device (*e.g.*, a catapult) which imparts a certain initial speed. In calculating the range of the rocket-torpedo we shall use Dr. Sänger's formulæ in his well-known book: "Raketenflugtechnik."

The accepted basis is as follows:—

(*a*) $G/G_0 = 0.4$ . . . . . (36)

(*b*) $v_0 = 80$ m./sec. $= 264$ ft./sec. . . . . (37)

(*c*) During upward flight the motion of the rocket-torpedo is uniform, with velocity vm.

(*d*) Angle ζ, according to Sänger's calculations, is optimum when:—

$$\zeta = 30^\circ \quad . \quad . \quad . \quad . \quad . \quad . \quad (38)$$

(*e*) The trajectory of upward flight is a straight line.

(*f*) $\epsilon = 0.1$ . . . . . (39)

(*g*) $vm = (v_0 + v)/2$ . . . . . (40)

Order of Calculation.

(*a*) Upward Flight.

From the equation:—

$$G/G_0 = 2k_1 - 1 \quad . \quad . \quad . \quad . \quad . \quad (41)$$

we calculate k_1.

From the equation:—

$$2k_1 - 1 = -\left\{\frac{r - v_0\sqrt{(k_1 \cos\zeta)}}{w}\right\}\left[\frac{15{,}700\, g\,(\sin\zeta + \epsilon\cos\zeta)}{v_0 v \sin\zeta\sqrt{(k_1\cos\zeta)}} + 1\right] \quad . \quad (42)$$

we calculate "r."

From the equation:—

$$t = \frac{15{,}700\left\{r - v_0\sqrt{(k_1\cos\zeta)}\right\}}{v_0 r \sin\zeta\sqrt{(k_1\cos\zeta)}} \quad . \quad . \quad . \quad . \quad (43)$$

we derive t.

The value of "s" is calculated from:—

$$s = v_m t \quad . \quad . \quad . \quad . \quad . \quad . \quad (44)$$

or from Sänger's equation:—

$$s = \frac{400{,}000}{\sin\zeta}\left[1 - \left(1 - v_0 t\sqrt{(k_1\cos\zeta)}\,\frac{\sin\zeta}{15{,}700}\right)^{1/25.5\sin\zeta}\right] \quad . \quad . \quad (45)$$

$$s_1 = s \cos \zeta \quad . \quad . \quad . \quad . \quad . \quad . \quad (46)$$
$$h = s \sin \zeta \quad . \quad . \quad . \quad . \quad . \quad . \quad (47)$$

(*b*) GLIDING FLIGHT.

$$s_2 = (1/\epsilon)\, h = 10\, h \quad . \quad . \quad . \quad . \quad . \quad . \quad (48)$$
$$p = s_1 + s_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (49)$$

Results of these calculations are given in Table X and in Fig. 2.

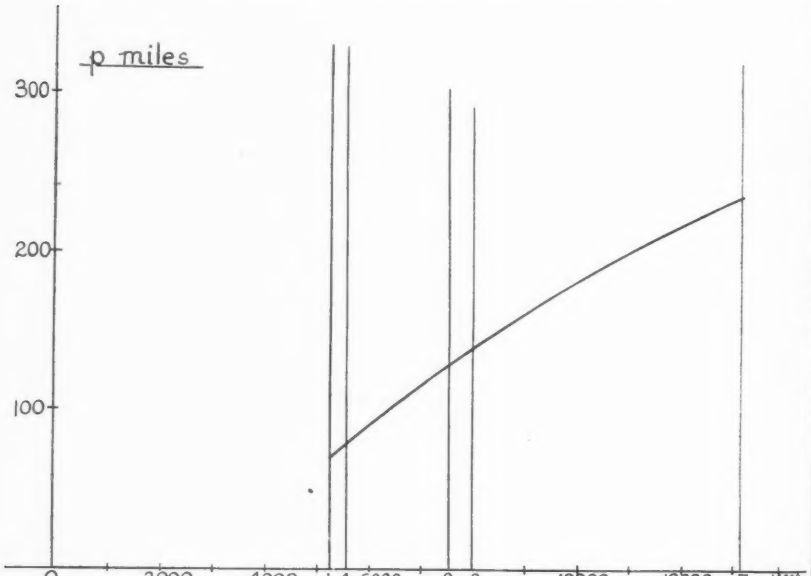

Fig. 2. p=f(w) for rocket-torpedo.

TABLE X.

Type of Working Material (from Table II.)			1	2	3	4	5
v	m./sec.	...	115	190	216	119	1,000
	ft/sec.	...	379	626	710	393	3,290
t	sec.	...	232	340	360	242	445
v_m	m./sec.	...	98	135	148	100	540
	ft./sec.	...	323	445	487	329	1,780
s	km.	...	22.70	45.85	53.20	24.20	240.00
(44)	miles	...	14.15	28.60	33.20	15.05	149.00
s	km.	...	19.20	35.00	38.50	21.10	64.20
(45)	miles	...	11.94	21.80	23.90	13.10	40.00
h	m.	...	9,600	17,500	19,250	10,550	32,100
	ft.	...	31,600	57,500	63,300	34,600	105,800
s_2	km.	...	96.00	175.00	192.50	105.50	321.00
	miles	...	59.80	108.80	119.60	65.60	200.00
p	km.	...	112.60	205.30	225.80	123.70	376.70
	miles	...	70.14	127.62	140.25	76.94	234.60

(It will be seen that formulæ (44) and (45) give different values of s.)

From Table X and Fig. 2 the following conclusions may be drawn :—

(*a*) The influence of type of working material is very important. Strong materials should be used.

(*b*) The distance traversed by the rocket-torpedo on the glide is much farther than that of upward flight.

(*c*) Following from (*b*), very high lift/drag ratios and aspect ratios should be employed.

(*d*) The ranges of rocket-torpedoes, as given by the approximate calculations, are very considerable, and are comparable with those of long-range artillery (*cf.*, " Big Bertha "). The problem of the rocket-torpedo is closely bound up with that of the pilotless aeroplane.

Conclusions.

Our approximate calculations showed that the range of wing-bombs is considerable and that the use of them might be very advantageous. Rocket-propulsion for wing-bombs also appears to offer advantages, but the influence of height and of optimum lift/drag and aspect ratio seems to be greater than that of rocket-propulsion. The range of the rocket-torpedo is comparable with that of long-range artillery. Whether the use of wing-bombs, rocket wing-bombs and rocket-torpedoes is practicable will be decided by the solution of constructional problems concerning the instruments for stability of flight, the propulsion motor, and the manufacture of large powder-rockets.

As regards rocket motors and folded-wing-rockets, we have already some very important and interesting results obtained by Prof. Goddard (U.S.A.), Dr. Sänger (Germany), and research workers in the U.S.S.R.

List of References.

1. C. Rougeron. " L'Aviation de Bombardement." Paris. 1937.
2. L. Kort. Raketen mit Strahlapparat. Z.F.M., No. 16, Aug. 27, 1932.
3. Engl. Lufttorpedo. Flugsport, 1936. 2 Sept. p. 451. (Engl. Patent 317774.)
4. Dr. Ing. Eugen Saenger. Raketen-Flugtechnik. München and Berlin. 1933.

REVIEWS.

The Analysis of Engineering Structures.

A. J. S. Pippard, M.B.E., D.Sc., and J. F. Baker, M.A., D.Sc. Arnold and Co. 1944. 30/- net.

This is the second edition of a work first published in 1936. It is no mean feat to bring out a new and revised edition of a technical book in wartime, and the authors are to be congratulated on having made the effort, for this is an excellent textbook.

A considerable amount of new matter has been added in the text, as well as two completely new chapters. Among the new matter added may be noted the general form of Clark Maxwell's reciprocal theorem; principle of superposition applied to redundant frameworks; derivation of strut formulæ from polar diagrams; extra examples on stiff-jointed frames; the rectangular and T reinforced beams with tension reinforcement; adhesion and bond; stresses in an extensible suspension cable; mechanical methods of plotting influence lines; and experimental analysis of stresses in wings.

Two important chapters have been added on the Voussoir arch and the behaviour of structures in the elasto-plastic range. The Voussoir arch is one of the earliest forms of bridge and building construction and much theoretical and practical analysis has been expended upon it. One of the authors and others carried out a most interesting experimental study of this type of construction over a number of years, clearing up many doubtful points of strength and stability.

The final chapter on the Behaviour of Structures in the Elasto-Plastic range is important, and will become of increasing importance in future editions.

" Analysis of Engineering Structures " can be thoroughly recommended.

Triumph Over Tunisia.

Wing-Com. T. H. Wisdom. Allen and Unwin. 1944. 8/6.

Wing-Commander Wisdom will be remembered as the author of a vivid and well-written book on the Greek campaign, called " Wings Over Olympus." His present narrative is equally vivid but less well-written, showing traces of hurried composition and deficient proof-reading—for a writer of his calibre ought to avoid such mistakes as " he laid on deck," " victoire anglais." Someone really should impress on Mr. Wisdom, too, that there are accents in the French language, and that the Italians do not call their air force " Regio Aeronautica." (This slip, already made more than once in " Wings Over Olympus," recurs with irritating frequency in the present book.)

In other respects the story makes good reading. Starting with the " dress rehearsal " Dieppe raid, it goes on to tell the tale of Squadrons No. 43 (Hurricane) and No. 111 (Spitfire), with their French, American and Empire colleagues, from the first landing in North Africa on November 8th, 1942, to the triumphal entry into Tunis on May 7th, 1943. The " hard facts and figures " of that six months are summed up as follows: 20,000,000 lb. weight of bombs dropped; 1,696 enemy aircraft destroyed in combat and 2,000 on the ground, for an allied loss of 657; 200 enemy air transports shot down in five weeks without loss; 26 Axis generals and 290,000 men captured.

As a whole, the book is less a record of hard facts than a miscellany of entertaining anecdotes. We liked the one about Professor Joad who, on a cross-

country journey in England, took a seat reserved for one of the pilots. " Bartley had politely protested: ' Do you mind, old man, but that seat belongs to one of my chaps.' Joad looked up, stared for a moment, and then remarked: ' I apologise for being old; I am. Nevertheless, I see no point in further continuing this conversation.' He promptly went fast asleep."

On the more serious side we have interesting sidelights on the preparations made for the initial landing in Tunis, the relations between the British and the French population, the Casablanca Conference, and the entry into Tunis. The book is the first to be written about the air war in Tunisia, and will certainly be read with enjoyment by a wide public.

THE MEN WHO FLY.

By Hector Hawton. Thos. Nelson and Sons. 1944. 5/-.

So much has been written upon aviation and everyone connected with it, that it has become almost impossible to be original. Flight Lieut. Hawton is therefore to be congratulated upon having approached his subject from a new angle. Hitherto, books about " The Men Who Fly " have either been highly technical works written by and for qualified doctors, or eulogies of " intrepid aviators " written by journalists for schoolboys. Here at last we have a reasoned psychological study that, while not beyond the schoolboy's grasp, makes interesting reading for the intelligent adult, however much or little he may know about flying.

A wide range is covered in a short space. We learn the principles upon which air crews are selected and trained; the successive phases of operational flying—the briefing, the flight itself, the procedure after return, the processes of parachute-jumping and ditching; the general structure of the R.A.F. All this information is co-ordinated to the main purpose of showing the physical and mental effect upon different individuals of a life that, from many points of view, is abnormal. A final chapter, of interest to everyone, deals with the future prospects of the pilots of to-day—especially those who have passed straight from school into the R.A.F., knowing no trade but war.

This book keeps up the high standard that we associate with Nelson's " Aeroscience Manuals," and should have a wider public than the more exclusively technical works in the series.

AMERICAN WAR PLANES IN ACTION.

By S. E. Veale. The Pilot Press. 1944. 5/-.

Recently there have been several books treating American aircraft from a recognition standpoint, but Mr. Veale's, in addition to its beautiful photographs of some 50 different types, also tells us what American military aircraft have actually achieved. The very frank first chapter, discussing their operational qualities, should be read by everyone. In subsequent chapters new details are given about the Tokyo bombing raid, the battles of the Coral Sea and of Midway; there are also succinct accounts of the development of the U.S. Air Forces and aeronautical industry. Useful features are the tables explaining the prefixes used to denote different types, and the classified list of all American military aeroplanes, with their names and numbers.

TEACH YOURSELF ASTRO-NAVIGATION.

By " Kaspar " (Flight Lieut. S. R. Millard). English Universities Press, Ltd. 1943. 3/-.

It would be a bold man who undertook to " teach himself " Astro-Navigation, and a still bolder who entrusted himself to a self-taught Astro-Navigator; but, to give the author his due, he has anticipated this criticism by stating explicitly in his preface that he is writing for Higher School Certificate students and for

R.A.F. trainees who wish to supplement their short practical Astro course by some theoretical knowledge. For such purposes this is a useful text-book, covering the elements of the subject in a manner that is not too abstruse for a student who already has a groundwork of mathematics and trigonometry. There are no set questions, but each point is illustrated by an example worked out in full, which the student is advised to follow out, step by step, for himself.

AERODYNAMICS OF THE AEROPLANE.

W. L. Cowley. Nelson's Aeroscience Manuals. 5/- net. 1943.

A number of books in this series, all under the general editorship of Professor H. Levy, have been reviewed in the Journal and praised for their contents and printing. This book is no exception. This is, indeed, one of the best series which has been published for many a long day in the field which they cover.

Mr. Cowley is a well-known member of the Royal Aircraft Establishment. He modestly says in his preface that the book gives only a very elementary survey of present day aerodynamic conceptions. It is an over-statement, for any student who reads through the book will find himself so gently led up the aerodynamic path that he will be able to go on to those fatter volumes of aerodynamics which, at a first glance, make the average student feel he will never get a real grip of the subject.

The author takes us from the flow of water in the common tap to wing and tail flutter. From the tap the student can immediately and practically find out the effects of fluid motion. There are chapters on the aerofoil, propeller, the aeroplane in steady flight, aerodynamic measurements, aerofoil theory, unit motion and vibrations in aircraft, together with examples on each chapter.

There are parts of the book which the student will have to read carefully before he can grasp fully the essentials, as for example the chapter on propellers.

As many have done before him, and doubtless many will do after him, the author has tried to explain the distinction between mass and weight. Mr. Cowley does not solve the problem by saying mass is the quantity of material in a body.

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